

Acoustic Communication for UUVs

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LONG TERM GOALS

The Office of Naval Research is sponsoring the development of acoustic communication modems for unmanned undersea vehicles. This effort is an enhancement to the Acoustic Communications (ACOMMS) ATD, focusing on a demonstration of UUV to SSN acoustic connectivity. The long term goal is to determine whether ACOMMS is sufficiently mature to warrant use on Navy UUVs currently under development, and to demonstrate the usefulness of the technology for data telemetry, bi-directional communication and UUV control.

OBJECTIVES

This project is developing and testing an acoustic modem for the Florida Atlantic University (FAU) UUV. This 21" x 9' vehicle is representative of current and near-term Navy UUVs and is an inexpensive testbed. The main objective is to demonstrate robust bi-directional ACOMMS between this UUV and a 688-class SSN. In particular, the project seeks to determine whether ACOMMS is currently sufficiently robust for extended, high throughput bi-directional communications between UUVs and Navy platforms.

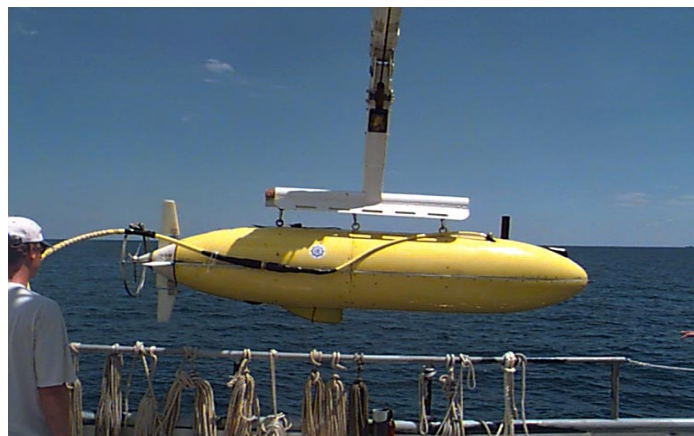


Figure 1: FAU UUV showing ACOMMS projector and towed array attachment

APPROACH

ACOMMS on UUVs is difficult because of the limited acoustic aperture, high self-noise levels, and greater autonomy/reliability required on the platform. Previous efforts at demonstrating ACOMMS were largely unsuccessful because of the above three limitations. Our approach addresses these problems through several fallback strategies:

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1. UUV acoustic aperture and self-noise limits were overcome by the use of a short towed array. The towed array allowed a comparison between on-board and free-field sensors and an assessment of performance degradation resulting from use of on-board hydrophones.
2. Both medium frequency (MF) and high frequency (HF) modems were installed and tested on the vehicle. While the primary modem on the vehicle is the HF system, the use of MF provided additional performance data and a fallback in case of unsatisfactory HF performance.
3. Robust UUV control methods were developed by FAU primarily for use with the sometimes-unreliable ACOMMS modem. The robust control algorithm compensates for ACOMMS packet dropouts and occasional data errors.

The testing schedule was designed to progressively tax the modem's capabilities. the testing starts with one-way ACOMMS between a UUV and RV, progressing to bi-directional UUV-RV tests, then to one-way UUV-SSN, and finally culminating in a bi-directional UUV-SSN ACOMMS demonstration. The frequent, progressively more ambitious experiments allow identification and timely correction of problems before moving to more ambitious tests.

WORK COMPLETED

In FY '97, an acoustic modem was installed on the FAU UUV and a one-way UUV-RV test was conducted in the vicinity of Newport, RI. This test demonstrated ACOMMS from the UUV at ranges up to 1500 m at 10 kbit/sec burst rate and aggregate data rate of 900 bits/sec.

In June '98, a bi-directional UUV-RV test was conducted at the Berry Islands Shallow Water Range in the Bahamas. During this test, the UUV was equipped with HF and MF acoustic modems, and with a video camera that was used to photograph the bottom and telemeter the compressed digital images to the RV. Acoustic conditions in the area were favorable, with isovelocity 90' deep water over a relatively flat sandy/coral bottom.

RESULTS

During the test, robust bi-directional HF ACOMMS was demonstrated at ranges up to 1000 m at the aggregate throughput rate of 900 bits/sec. Sporadic performance was achieved at ranges up to 1800 m. Burst data rates up to 10 kbits/sec were tested. Robust MF performance was achieved at ranges up to 3000 m at the aggregate throughput of 700 bits/sec. Burst data rates up to 2500 bps were tested. Sporadic performance was achieved at ranges up to 4500 m. Multiple images of the ocean bottom were taken by the UUV and acoustically transmitted to the RV. The UUV control algorithm was shown to operate robustly. Figure 2 shows a typical UUV trajectory during the test, illustrating execution of multiple, acoustically commanded missions.

IMPACT/APPLICATIONS

The FAU UUV has a robust bi-directional acoustic modem ready for tests and demonstrations with an SSN. Limited source levels on the UUV may preclude meeting long-range demonstration goals. In addition, the Power and DSP constraints on the vehicle will limit high aggregate throughput.

The upcoming UUV-SSN bi-directional demonstration will establish whether ACOMMS is sufficiently mature to be used for the transfer of large data files from UUVs to SSNs and vice versa. In particular, PMS 403 has requested that the program demonstrate the feasibility of transferring ~700 kByte files from the UUV to SSN, and the transfer of ~40 kbyte files from the SSN to the UUV. This

demonstration is scheduled for FY '99. A successful outcome will affect the future development of Navy UUVs.

TRANSITIONS

We are collaborating with the Navy UUV program office (PMS 403) to ensure that subsequent UUV ACOMMS demonstrations are useful risk-reduction exercises for the UUV platforms currently under development. This technology is transitionable to future navy UUVs.

RELATED PROJECTS

Acoustic COMMunicationS Advanced Technology Demonstration (ACOMMS ATD) is currently developing the related SSN and RV ACOMMS capabilities

REFERENCES

S. Smith et al: ACOMMS Operations June '98, report produced by the Advanced marine Systems Laboratory, Florida Atlantic University, July 1998

L. Freitag et al: 'A Bidirectional Coherent Acoustic Communications System for Underwater Vehicles', proceedings of the Oceans '98 conference, nice, France, October '98

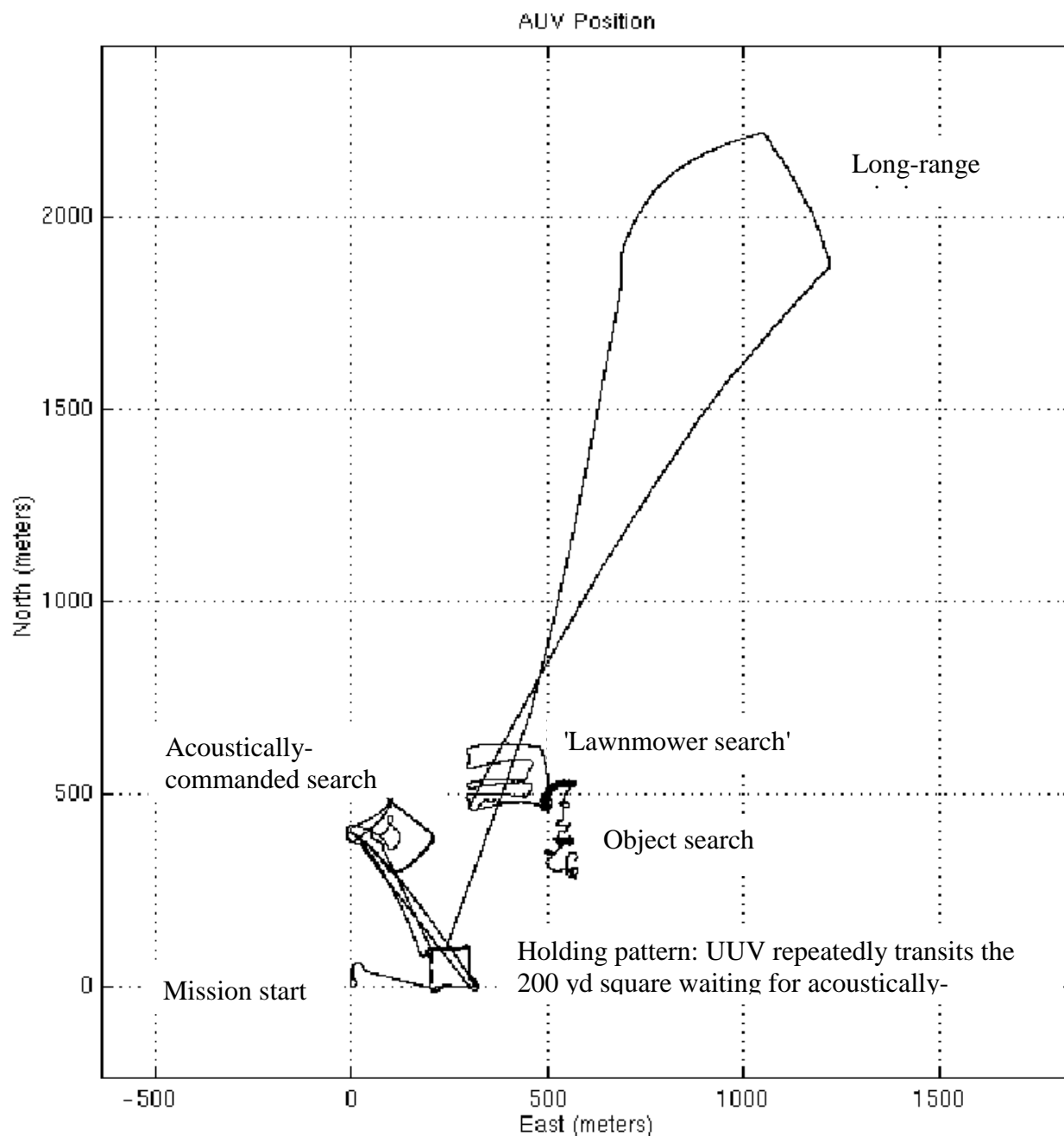


Figure 2: A typical UUV trajectory during the June '98 ACOMMS test. During this mission, the UUV was acoustically commanded to execute a number of different missions. (Figure generated at AMSL, FAU)